US Participation in JET Pellet Fueling Program

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US Program Could Benefit from Assisting JET by Building on Success with Inside Pellet Launch

- JET has large size, high magnetic field and high temperature plasmas
  - Well suited for pellet fueling studies – enhances AT/BP science
  - Ideal for evaluation of D/T pellet fueling scenarios
- Success with inside pellet launch confirms the importance of innovative launch trajectories for pellet fueling
- US pellet program expertise could enhance the JET program with additional modeling support and further exploitation of operational modes with pellets
  - Hardware components to explore alternative trajectories and for DT pellet fueling

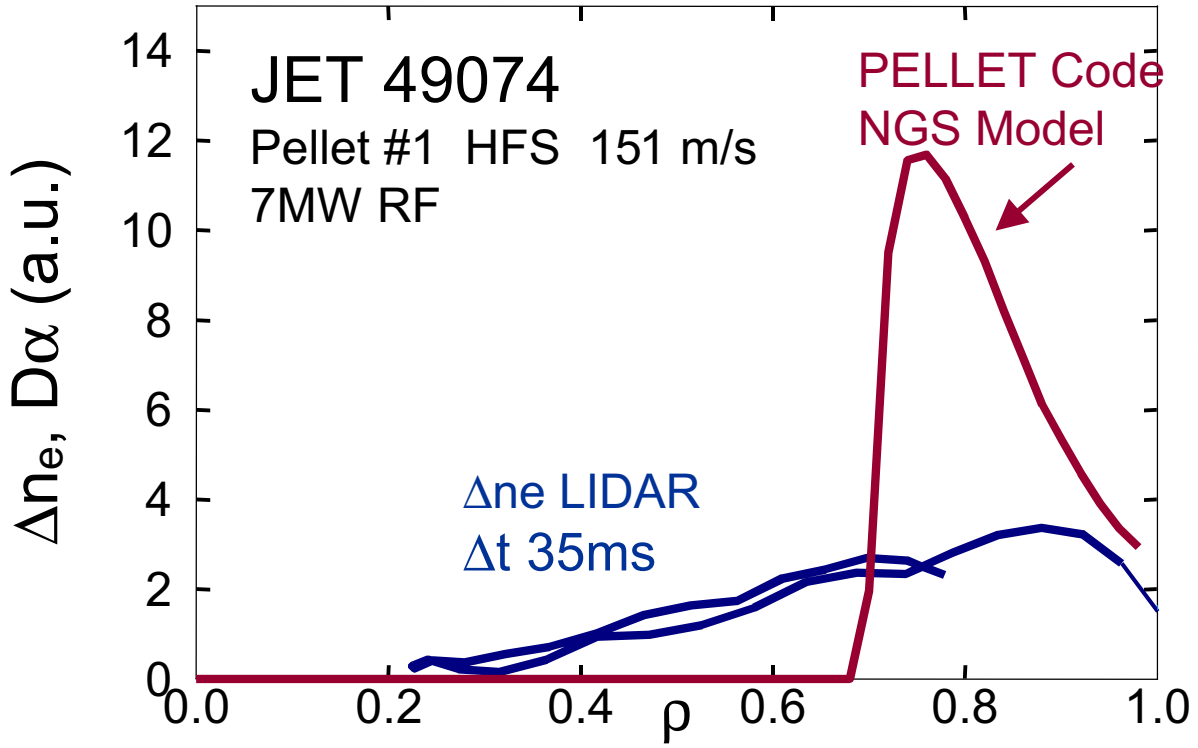
Possible Areas for US Participation in JET Pellet Program

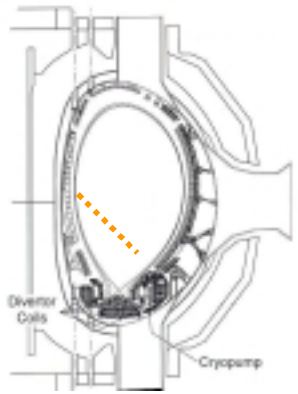
- Physics of pellet-plasma interaction
  - Improve understanding of pellet mass redistribution and penetration in JET plasmas
- Evaluation of alternate pellet fueling trajectories
- Preparation of new pellet equipment – “pellet injector in a suitcase” - deep fueling for ITB studies
- Evaluation and provision of future D/T pellet fueling components (DT extruder or TPI components from TFTR)
- Implementation and use of new pellet related diagnostics
- Exploitation of enhanced confinement plasma regimes with pellet fueling

Physics of Pellet-Plasma Interaction

- Modeling of pellet mass redistribution and penetration with pellet ablation models (started with JET experiments in1999)
- Comparison of inside and outside launch with DIII-D and ASDEX-U for size scaling studies (collaboration with P.Lang IPP and A.Geraud CEA)
- Modeling of deposition process with PELLET ablation code including an ExB drift model by Parks et al.
- Improved Modeling Capability with TSC that includes theoretical mass redistribution model
- Analysis of pellet launch induced ELM activity comparing inside and outside launched pellets

Determination of Pellet Deposition and Dα Mapping Has Been Achieved as Part of Collaboration Effort

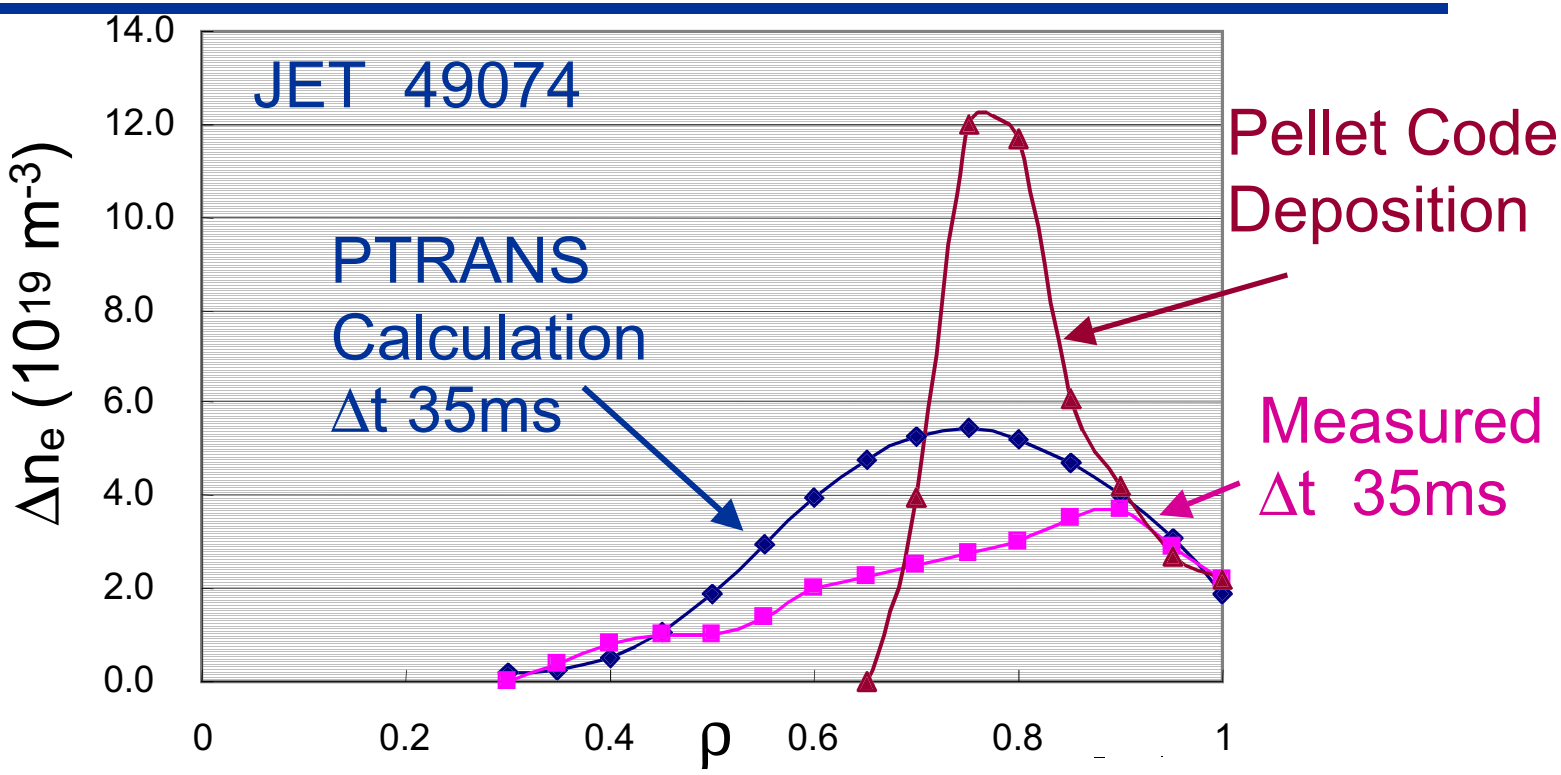




Dα emission Mapped onto Flux surfaces – (Pellet passes tangency point)

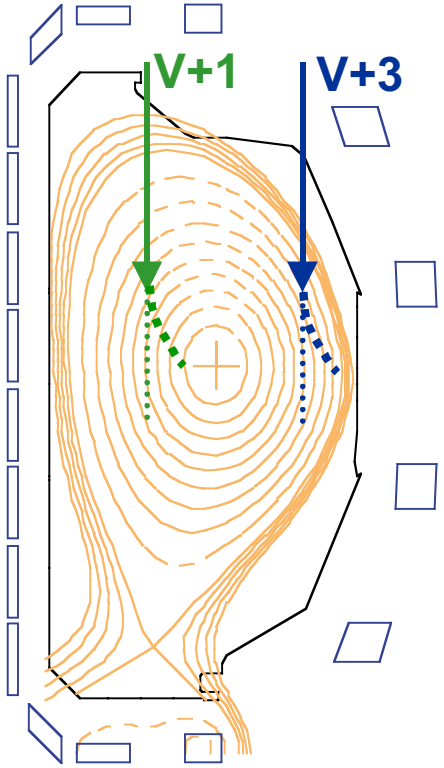
- Density perturbation from LIDAR compared with Dα emission and PELLET code calculation showing some inward mass redistribution.
- Deposition profile - calculated by PELLET code using measured Te profile.

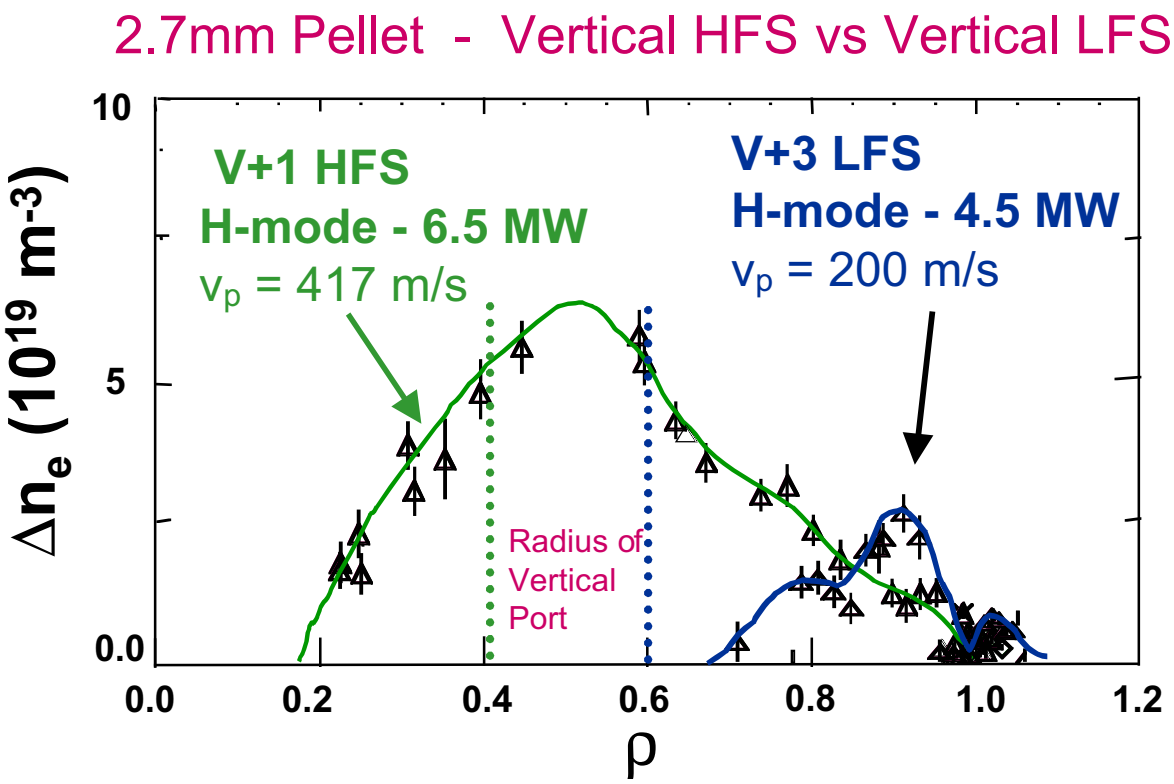
Support of Efforts to Model Radial Redistribution - Density Evolution Calculation Indicates Drift Effect Not as Strong as on DIII-D - Possible Trajectory Effect



- Density evolution of HFS pellet into L-mode plasma. Density evolved using PTRANS 1-1/2D code using transport model by Garzotti EPS2000.
- Deposition profile - calculated by PELLET code using measured Te profile.
- Drift effect with current JET HFS pellet trajectory is not dramatic. Better physics understanding is needed to extrapolate to next step device.

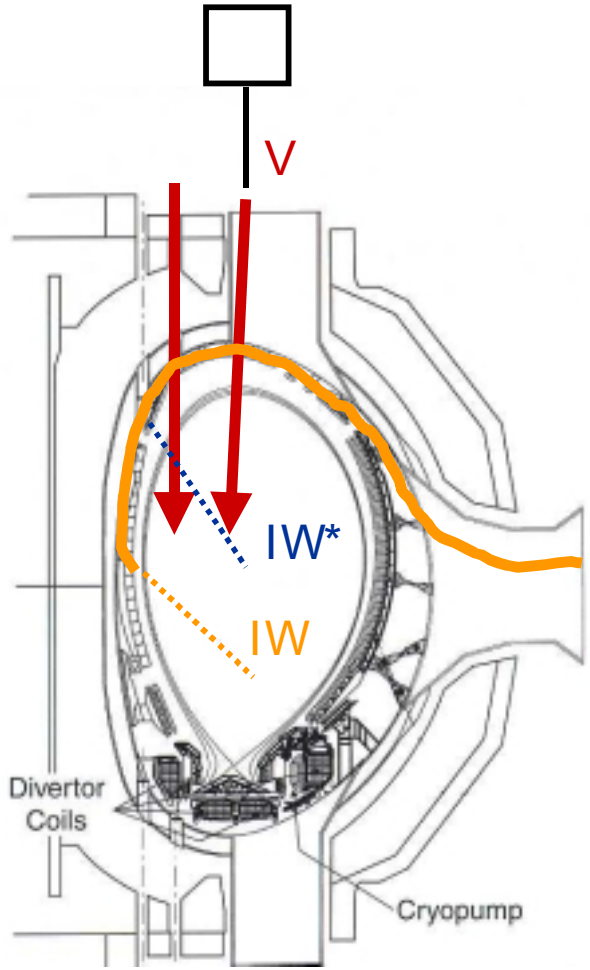
Both Vertical HFS and LFS Pellet Injection are Consistent with an Outward Major Radius Drift of Pellet Mass



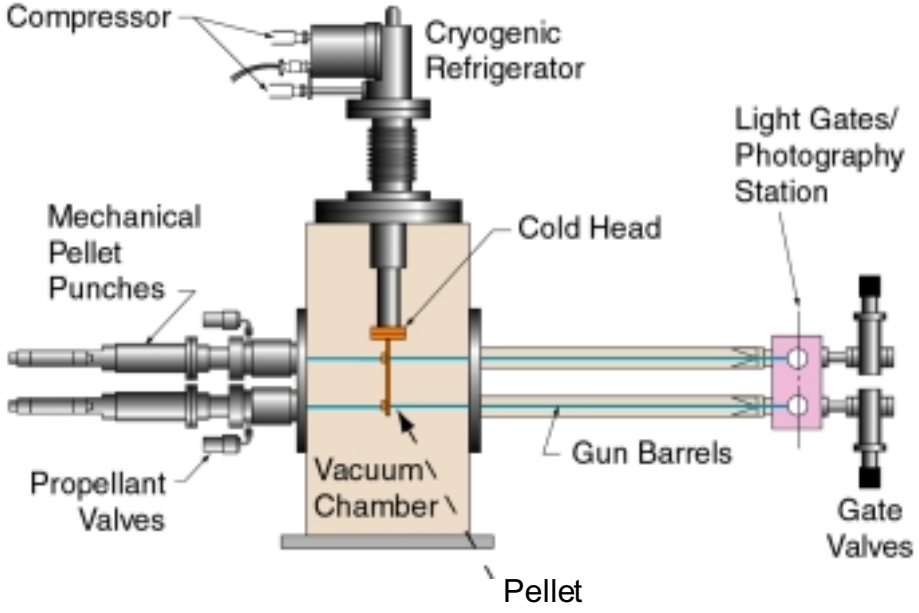


- The net deposition profile measured by Thomson scattering 2-4 ms after pellet injection on DIII-D. V+1 HFS indicates drift toward magnetic axis while V+3 LFS suggests drift away from axis.

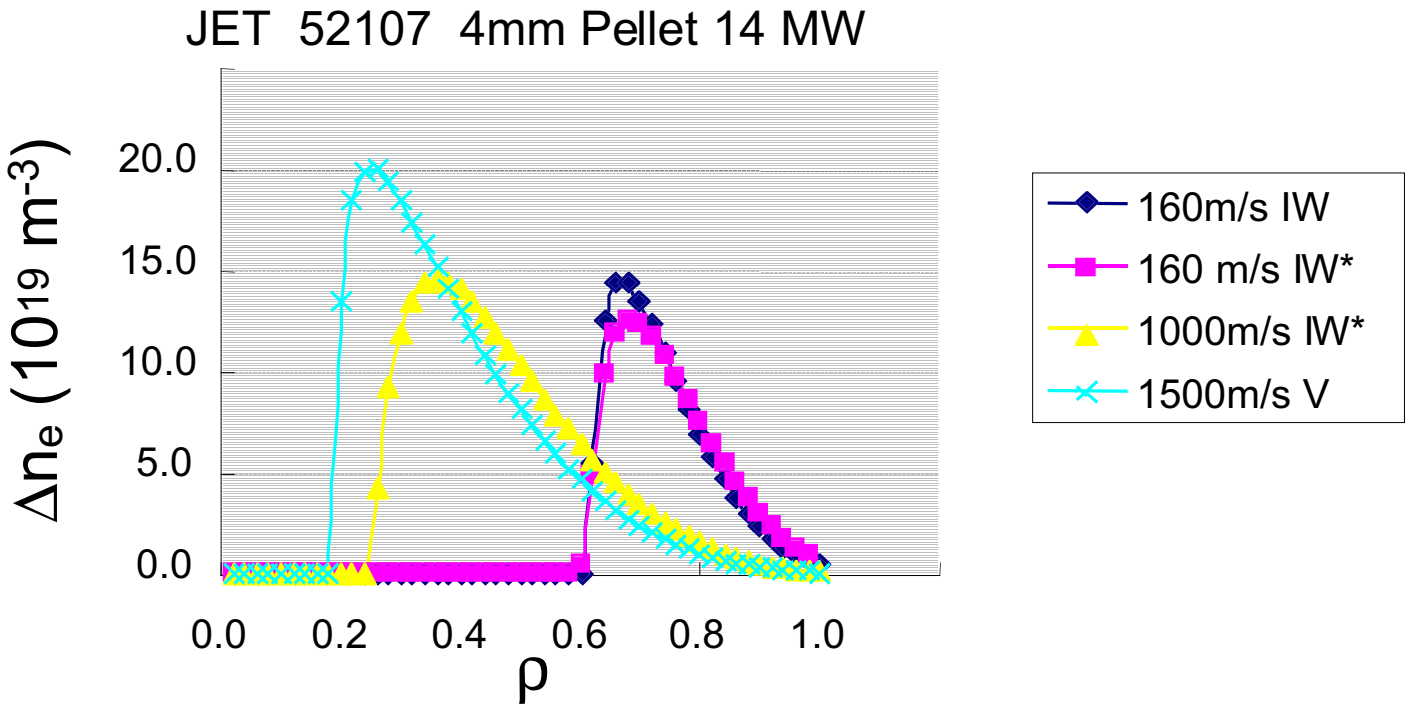
Possible Vertical Pellet Injection Test at JET



- **Pipe-gun injector for vertical pellet injection on JET**
  - **Complements existing JET inner wall injection with high-speed vertical pellets.**
  - **Simple "pellet injector in a suitcase" for flexible installation. 4 pellets.**
  - **Self contained cryo-refrigerator for simple operation.**
  - **For characterization of pellet drift physics in a large device.**
  - **If successful fueling is demonstrated, a more sophisticated system could be installed.**



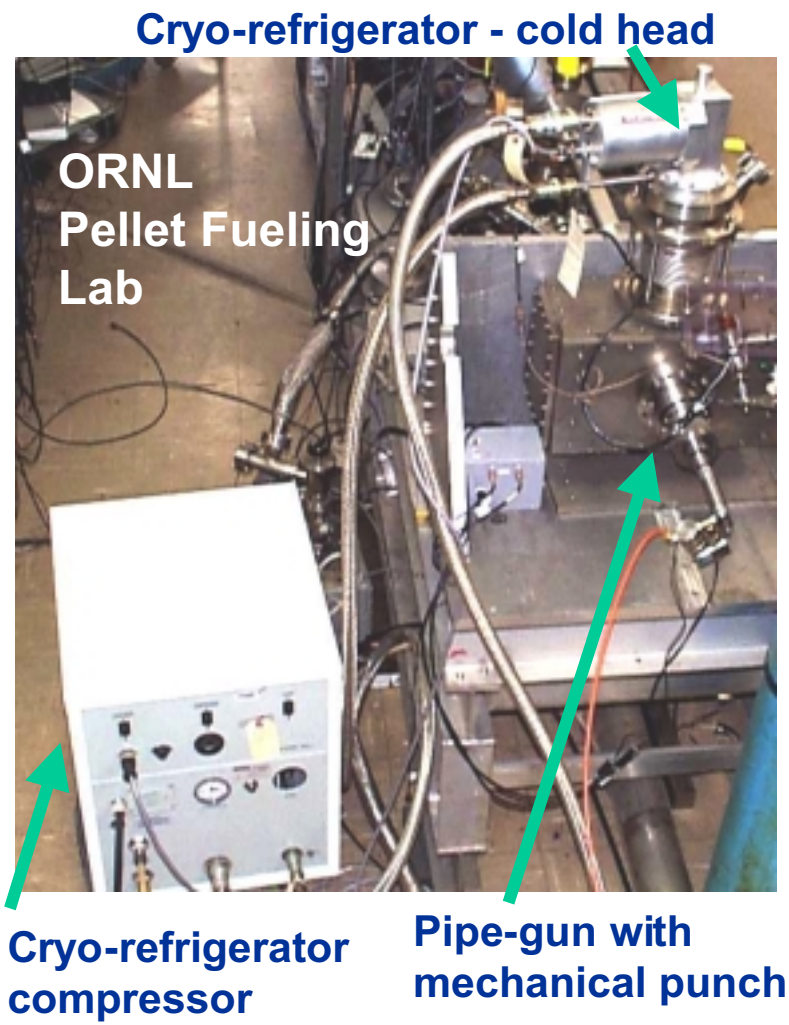
JET – Pellet Deposition from Proposed Trajectories



- Deposition profile - calculated by PELLET code using measured Te profile and EFIT equilibrium. No
- No drift effect included in calculation
- Vertical high speed pellet deposition similar to proposed modification to inside launch geometry.

Possible Pellet Hardware Related Elements for the ORNL Program at JET

- Pipe-gun injector for vertical pellet injection on JET - VLT development
  - Complements existing JET inner wall injection with high speed vertical pellets
  - Simple "pellet injector in a suitcase" for flexible installation - 4 pellets
  - For pellet drift physics and peaked density profile production for ITBs
  - Li or other solid pellet capable for Alpha charge exchange
  - Two-stage capable for high speed
- Tritium options for DT fueling with pellets.
  - ORNL tritium extruder experience coupled to JET centrifuge injector technology
  - Pipe-gun could also be used for DT



New Pellet Related Diagnostics

- Pellet injection experiments from different locations should emphasize pellet shielding and penetration effects

- New diagnostic installed on JET to extend pellet shielding studies

  High time resolution pellet cloud spectrometer

  - Will provide time resolved measurements of $D\alpha$ and $D\beta$ line widths and amplitudes

  - For the study of pellet ablation and shielding for inside and outside launch trajectories - comparison with DIII-D pellet clouds

Exploitation of Enhanced Confinement Plasma Regimes with Pellet Fueling

Participation in Experiments to Improve Physics Understanding

- High density pellet fueled ELMy H-mode experiments
  - Determination of transport properties – TRANSP analysis
  - Predictive modeling to optimize fueling scenarios for JET and future devices
- Pellet injection to perturb and form ITB plasmas
  - Compare the influence of inside vs outside launched pellets on the establishment of ITBs and investigate core confinement inside the barrier
  - Modeling to determine transport properties
  - Vertical pellet hardware for PEP ITB formation and ITB studies